MULTISPECTRAL COMPOSITES AND NEXT-GENERATION ADVANCED SATELLITE IMAGERS

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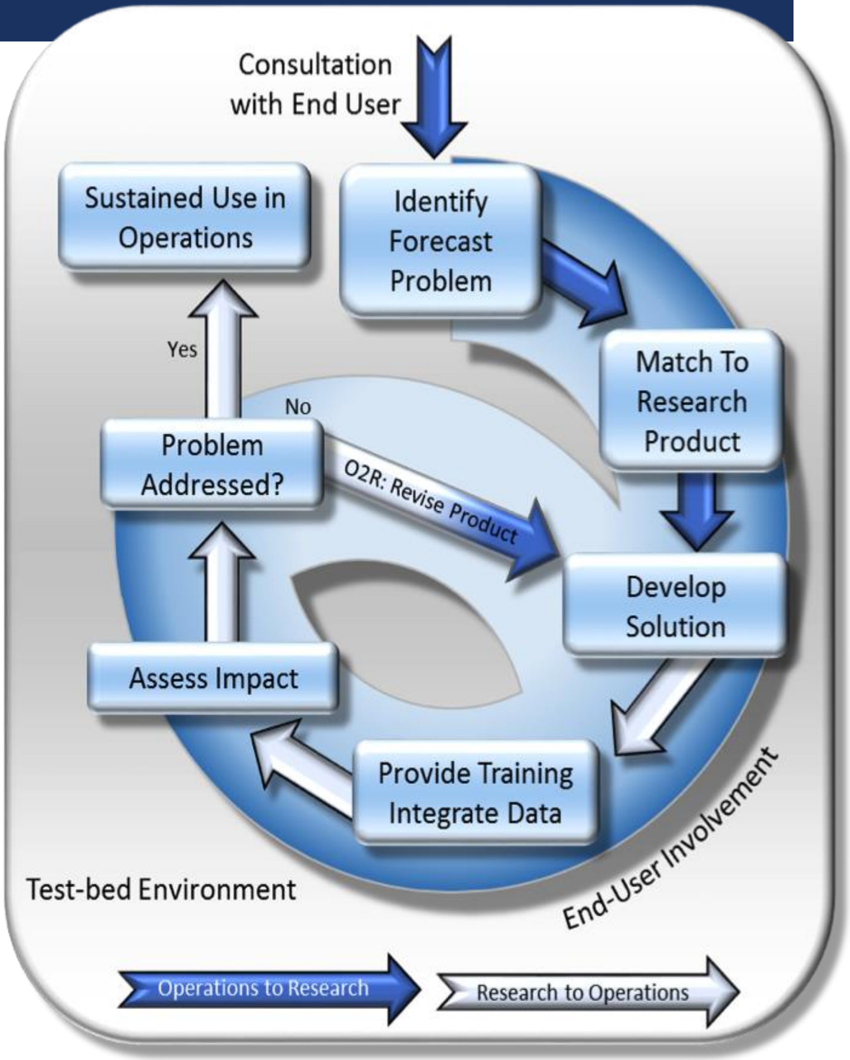
Short-term Prediction Research and Transition Center

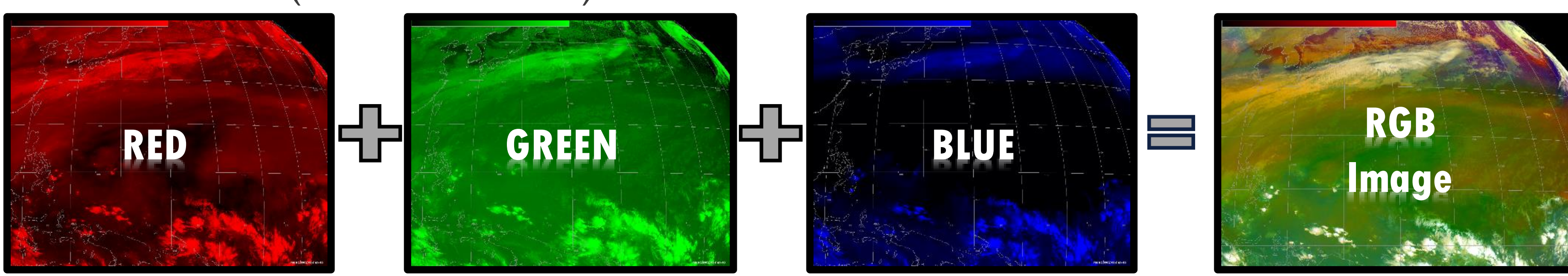
NASA/SPORT MISSION AND PARADIGM

- ***Apply satellite measurement systems and unique Earth science research to improve the accuracy of short-term weather prediction at the regional and local scale***
- Bridge the "Valley of Death" between research and operations
- Can't just "throw data over the fence"
  - Maintain collaborative partnerships with end users via help of local "SPoRT" advocates
  - Integrate product into user decision support tools for use with existing data
  - Create forecaster training on product utility
  - Perform targeted product assessments to determine operational value
- Concept has been used to successfully transition a variety of satellite datasets to operational users for nearly 10 years



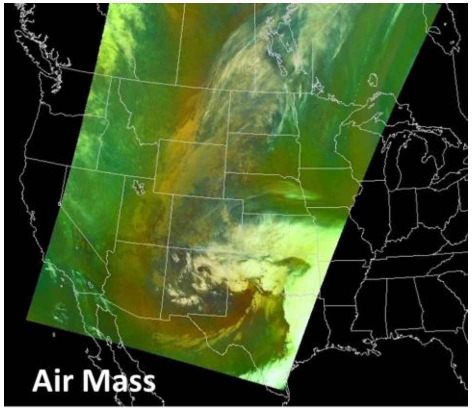
INTRODUCTION

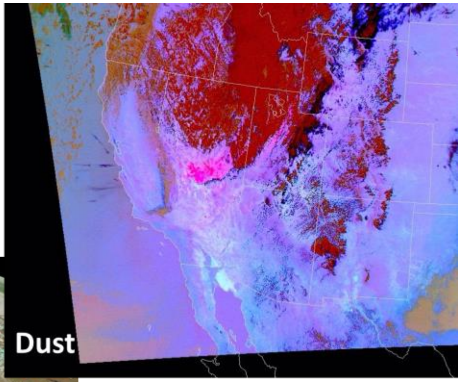
- EUMETSAT began creating Multispectral Composite (i.e. RGB) imagery in the early 2000s with the launch of Meteosat Second Generation Spinning Enhanced Visible and Infrared Imager (SEVIRI)
- RGB imagery is the use of single channels or channel differences combined into each of the red, green, and blue color components, resulting in a false-color composite related to multiple atmospheric and land-surface features
- RGB products are qualitative in nature are designed to enhance a specific phenomena such as low clouds and fog, dust, convection, air mass characteristics, or volcanic ash
- SPoRT has invested research in creating consistent Multispectral Composite (i.e. RGB) imagery across different sensors onboard polar-orbiting and geostationary satellites (Elmer et al. 2016)

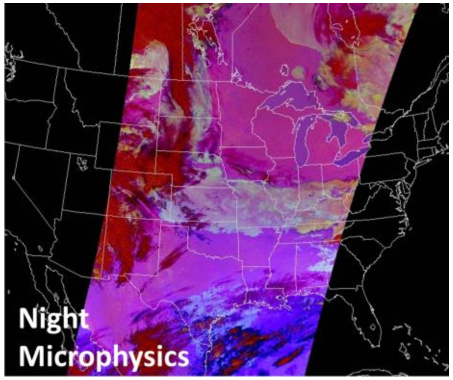


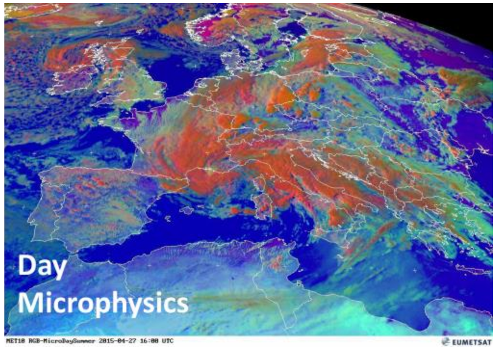
INTRODUCTION

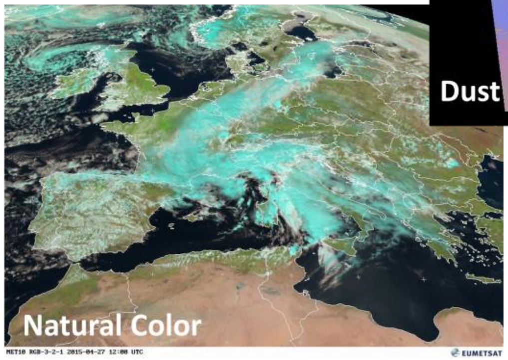
- EUMETSAT developed a set of best practices to identify a minimum set of multispectral composites based on MSG SEVIRI
- The best practices recommend adjusting the RGB recipe when creating RGBs with instruments such as the Moderate Resolution Imaging Spectroradiometer (MODIS) due to differing spectral and absorption characteristics across sensors
- Differences in band central wavelength, bandwidth, response functions and atmospheric absorption between sensors can result in inconsistencies in an RGB composites from sensor to sensor





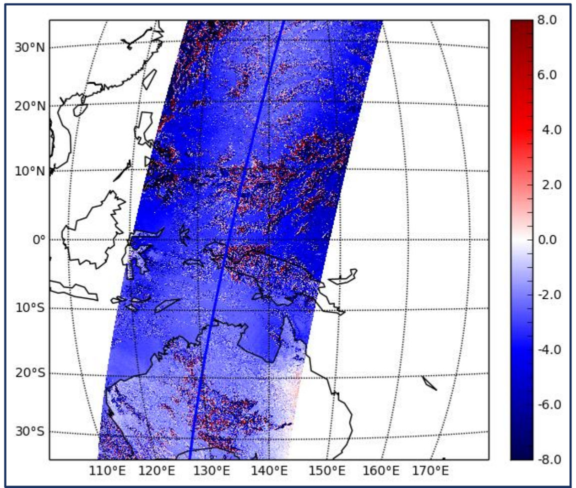






METHODOLOGY

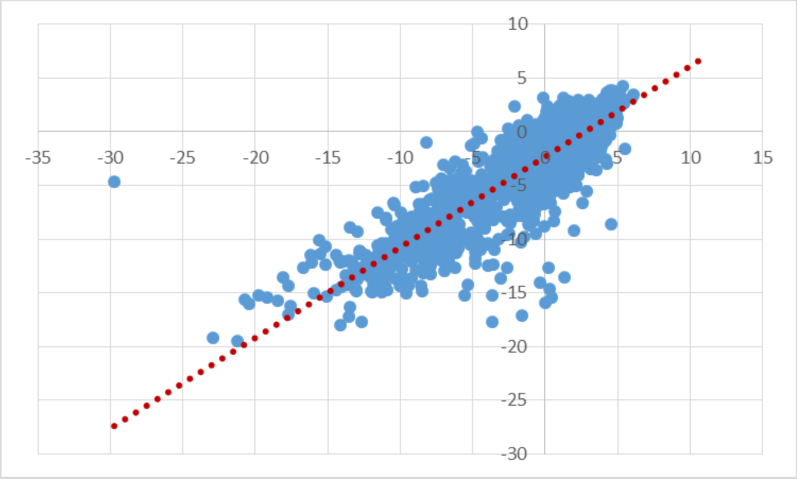
- For the purpose of comparing RGB composites derived from different sensors, Elmer et al. (2016) developed an offset correction to account for differences in band spectral response
- The offset correction and limb correction was applied to VIIRS to create a reference sensor or SEVIRI proxy
- Brightness temperatures for the SEVIRI proxy and AHI were compared over cloud-free ocean scenes at shared nadir points and less than 10 minutes apart similar to Cao et al. (2014) and Wu et al. (2012)
- Since atmospheric and surface changes are negligible at shared nadir points (cloud-free ocean scenes), any differences in brightness temperature between the two sensors can be attributed solely to differences in band spectral response



Difference between AHI and SEVIRI proxy for comparable 3.9 µm bands

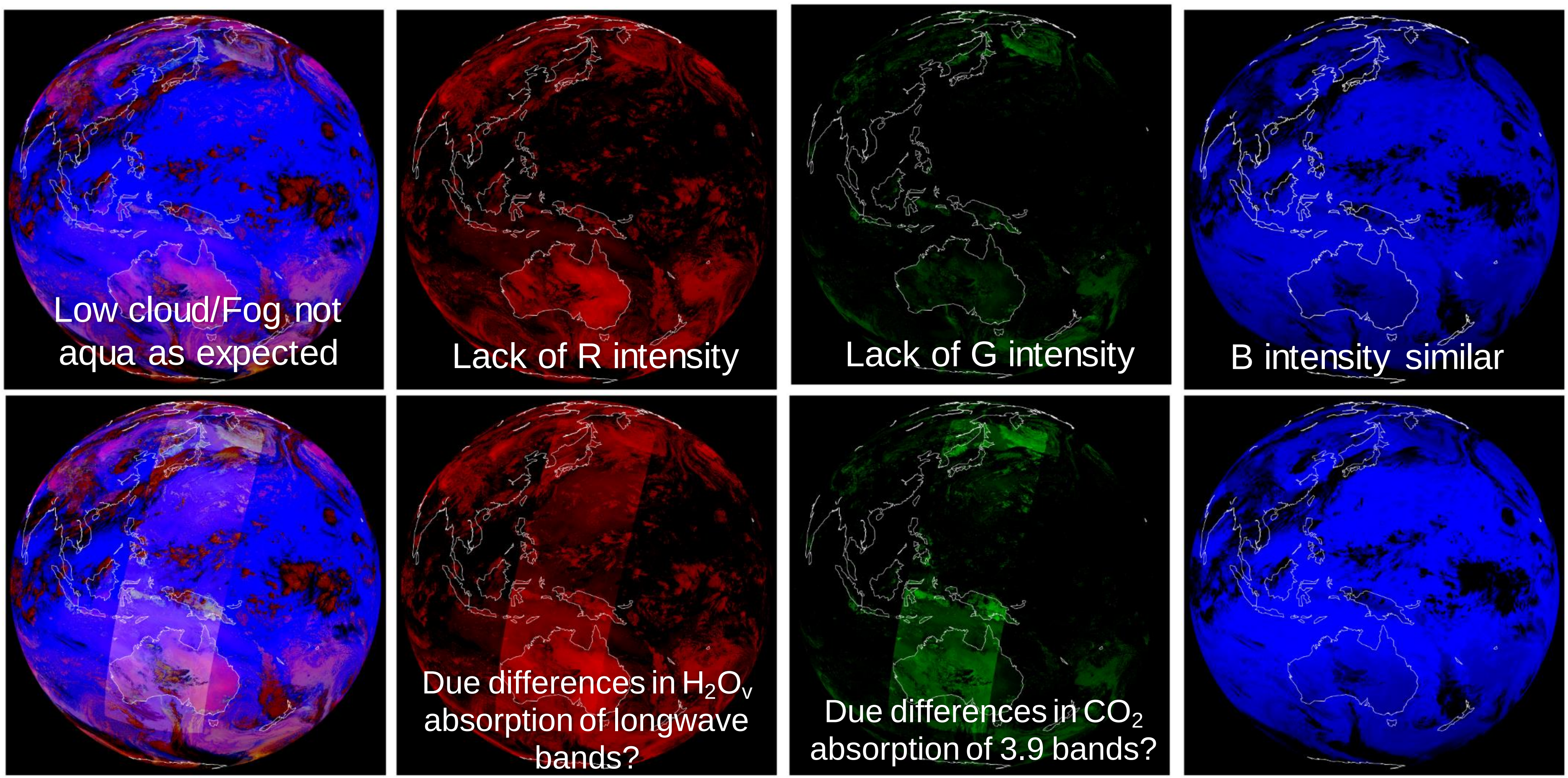
METHODOLOGY

- The relationship between measured brightness temperature of the SEVIRI proxy and AHI was compared though linear regression
- The linear regression coefficients were then applied to the EUMETSAT RGB component minimum and maximum values similar to Shimzu (2015) to determine RGB recipe adjustments
- By adjusting the recipe to account for differences in spectral characteristics and response the result is RGB imagery consistent with legacy EUMETSAT images and interpretation



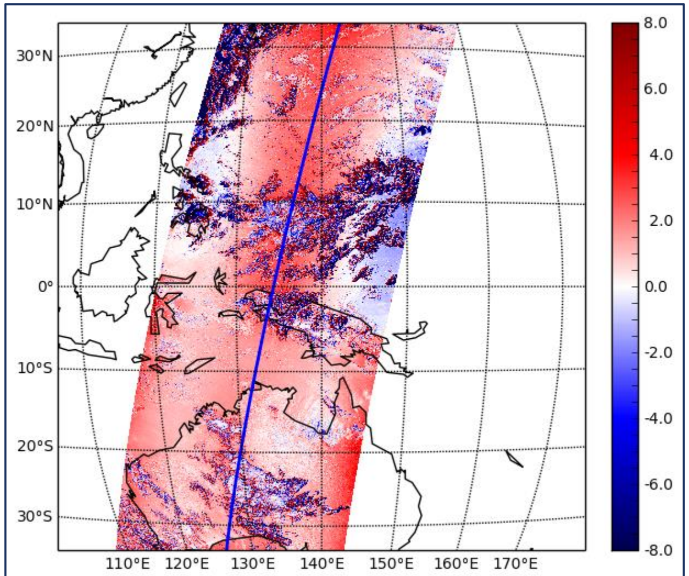
NIGHT-TIME MICROPHYSICS RGB

- AHI RGB coloring and component intensities differ from the SEVIRI proxy overlay

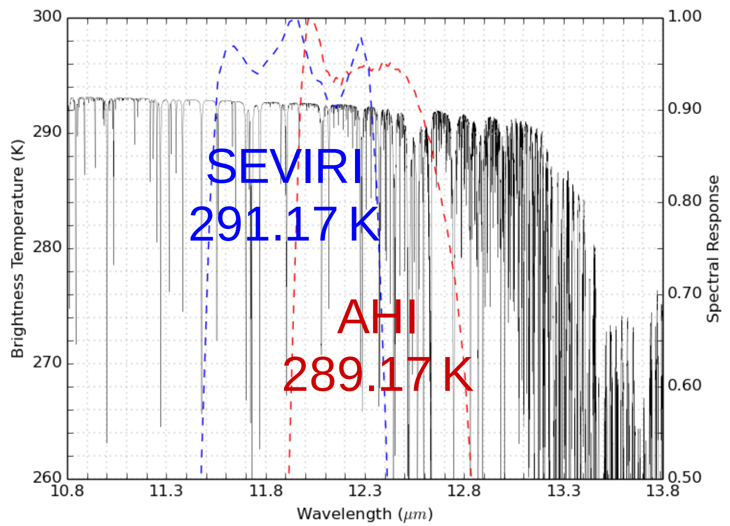


COMPARABLE 12.0 MICRON BANDS

- Case study data show SEVIRI proxy 12.0 *µm* is 2 to 4 K warmer than AHI 12.4 *µm*
- LBLRTM simulations confirmed the 2 K offset
- Despite a narrower range than SEVIRI, AHI 12.4 *µm* shifted to a region with more water vapor absorption and results in cooler measured brightness temperatures



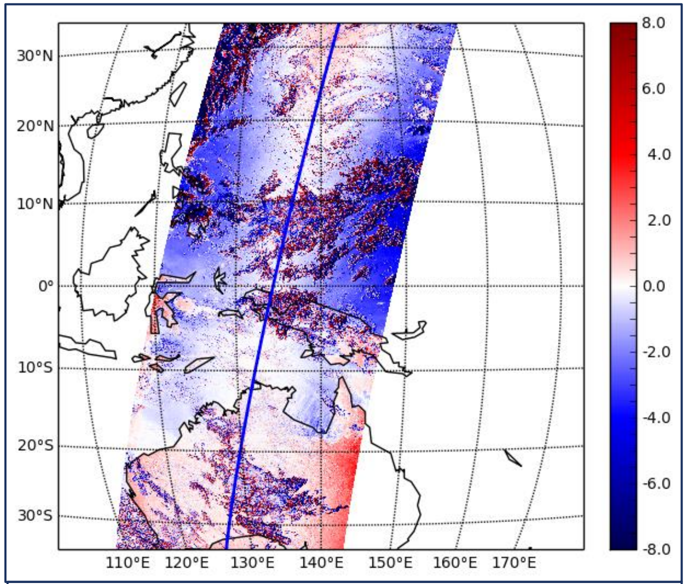
Difference between AHI and SEVIRI proxy for comparable 12.0 µm bands



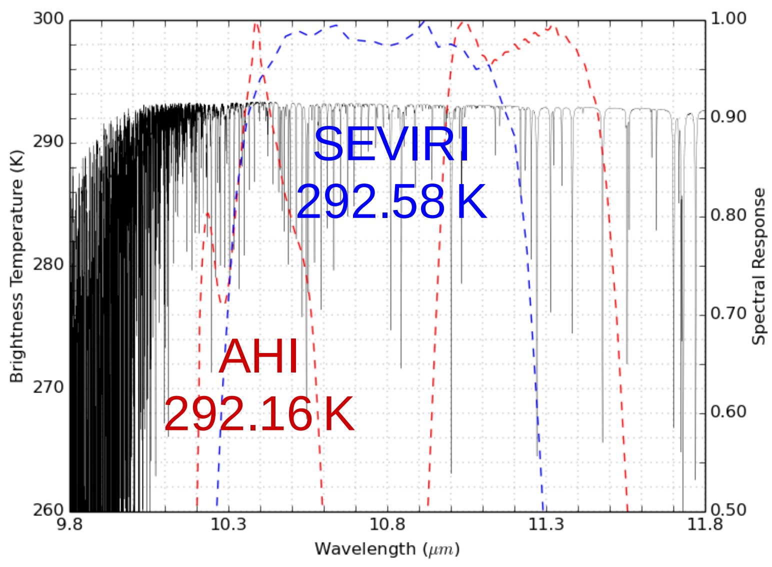
LBLRTM simulation using the U.S. Standard atmospheric profile, nadir viewing (100 km to surface) brightness temperature (Black), SEVIRI (blue) and AHI (red) spectral responses

COMPARABLE 10.8 MICRON BANDS

- Case study data show SEVIRI proxy 10.8 *μm* is nearly equal, slightly warmer than AHI 10.4 *μm*
- LBLRTM simulations confirmed the slight offset
- Brightness temperatures are similar in the atmospheric window despite shifted AHI central wavelength and narrow spectral range



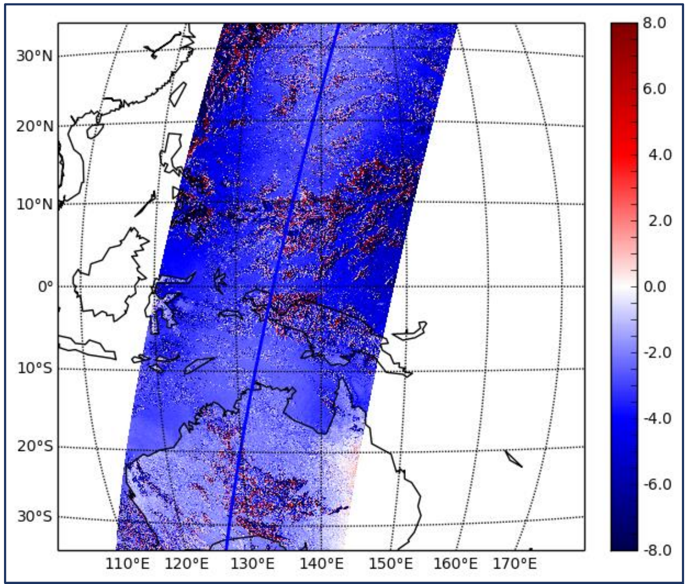
Difference between AHI and SEVIRI proxy for comparable 10.8 μm bands



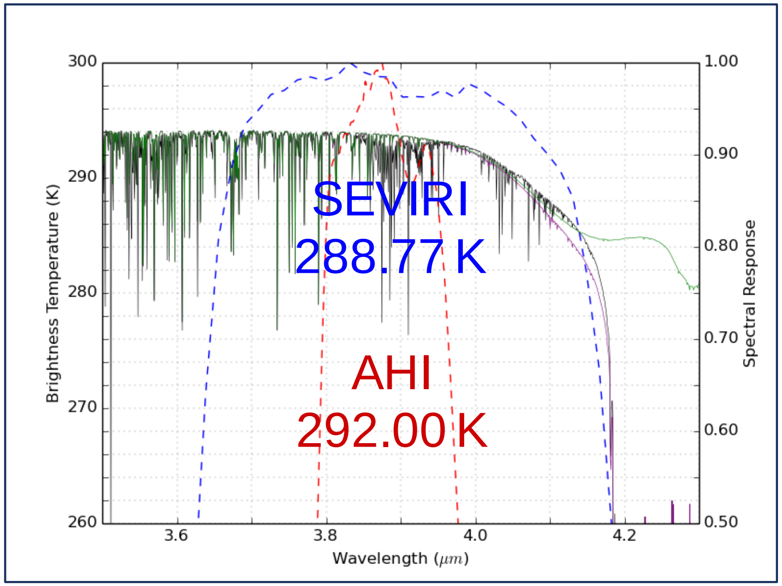
LBLRTM simulation using the U.S. Standard atmospheric profile, nadir viewing (100 km to surface) brightness temperature (Black), SEVIRI (blue) and AHI (red) spectral responses

COMPARABLE 3.9 MICRON BANDS

- Case study data show SEVIRI proxy 3.9 *μm* is 2 to 4 K cooler than AHI 3.9 *μm*
- LBLRTM simulations confirmed the offset
- AHI 3.9 *μm* brightness temperature are warmer since the band is not influenced by carbon dioxide absorption due to narrow spectral range



Difference between AHI and SEVIRI proxy for comparable 3.9 μm bands



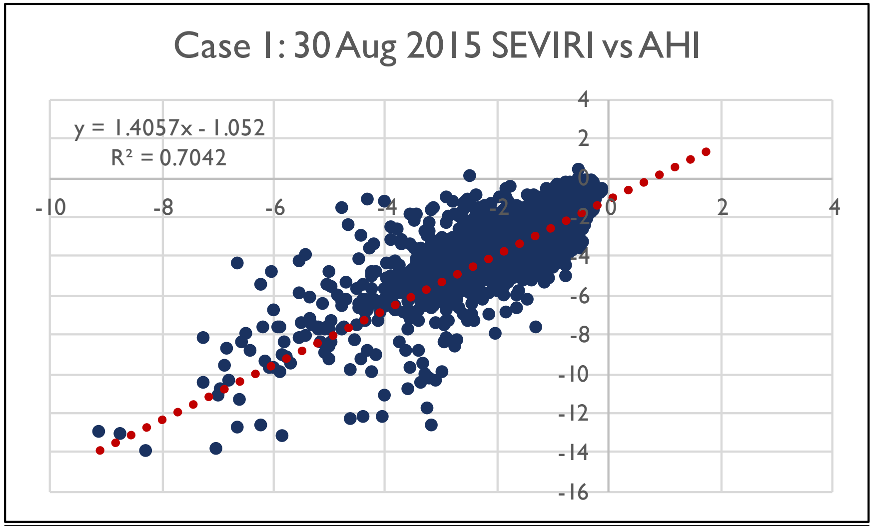
LBLRTM simulation using the U.S. Standard atmospheric profile, nadir viewing (100 km to surface) brightness temperature for 7 gases (Black), H_2O_V and CO_2 (Purple), H2Ov only (Green), SEVIRI (blue) and AHI (red) spectral responses

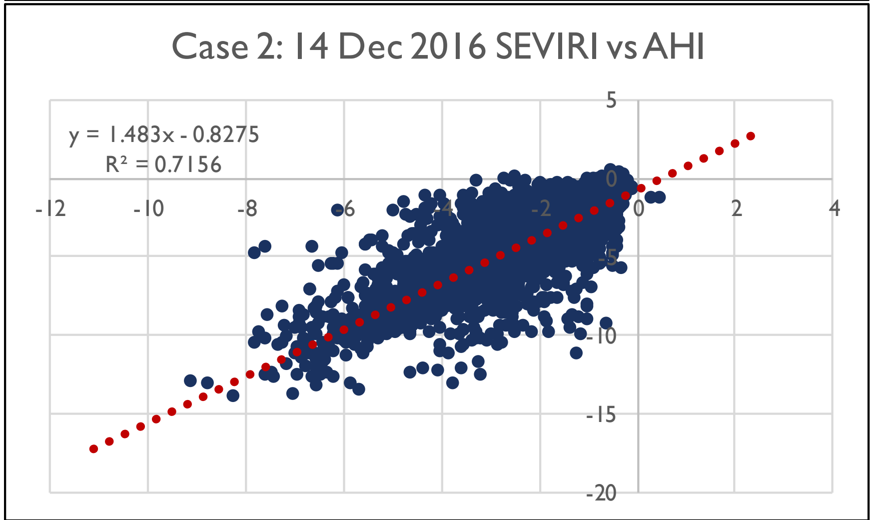
LINEAR REGRESSION: RED COMPONENT ADJUSTMENT

- Scatter plots and linear regression for two case studies used to determine recipe adjustments

Night-time Microphysics RGB				
Component	Band/Band Difference	Min	Max	Gamma
R	12.0 – 10.8	-4 K	2 K	1.0
G	10.8 – 3.9	0 K	10 K	1.0
B	10.8	243 K	293 K	1.0

- For Case 1, new range = -6.7 to 1.8
- For Case 2, new range = -6.7 to 2.1
- JMA adjustment = -6.7 to 2.6
- Results suggest adjustment:
  - Is not seasonally dependent
  - Is on par with JMA adjustments which were based on simulated data



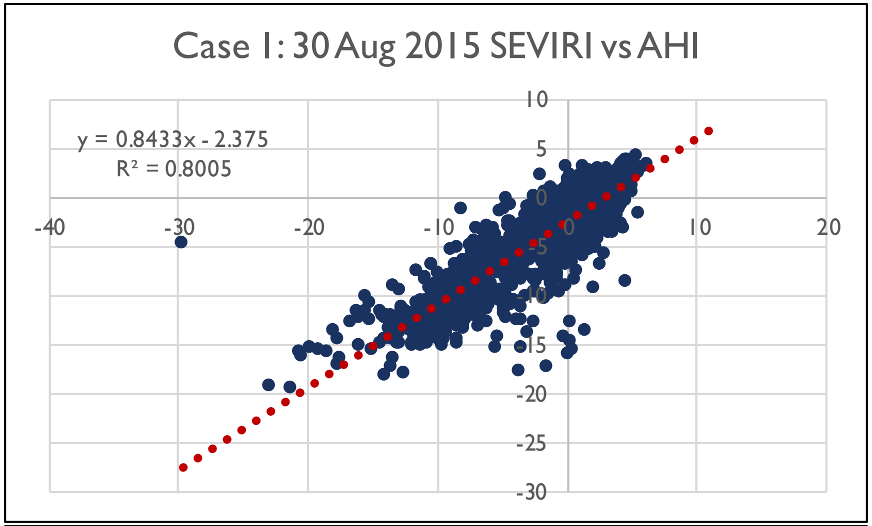


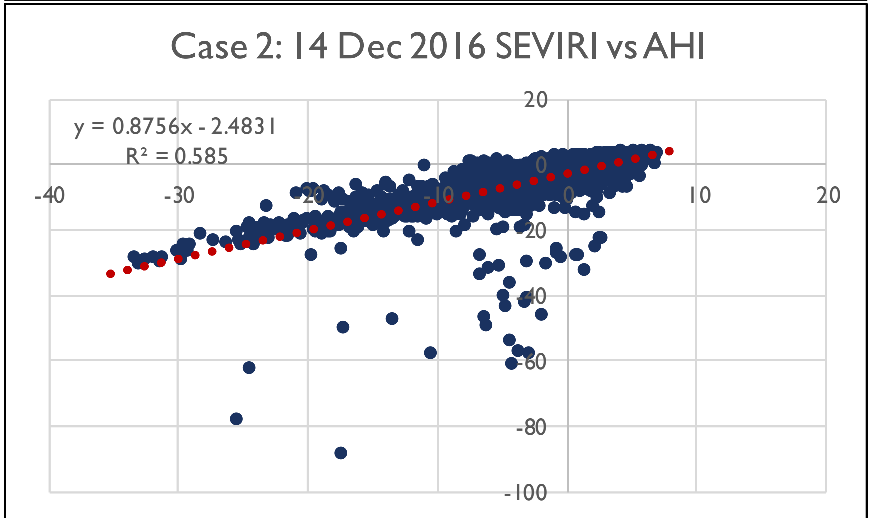
LINEAR REGRESSION: GREEN COMPONENT ADJUSTMENT

- Scatter plots and linear regression for two case studies used to determine recipe adjustments

Night-time Microphysics RGB				
Component	Band/Band Difference	Min	Max	Gamma
R	12.0 – 10.8	-4 K	2 K	1.0
G	10.8 – 3.9	0 K	10 K	1.0
B	10.8	243 K	293 K	1.0

- For Case 1, new range = -2.4 to 6.1
- For Case 2, new range = -2.4 to 6.4
- JMA adjustment = -3.1 to 5.2
- Results suggest adjustment:
  - Is not seasonally dependent
  - Is on par with JMA adjustments which were based on simulated data



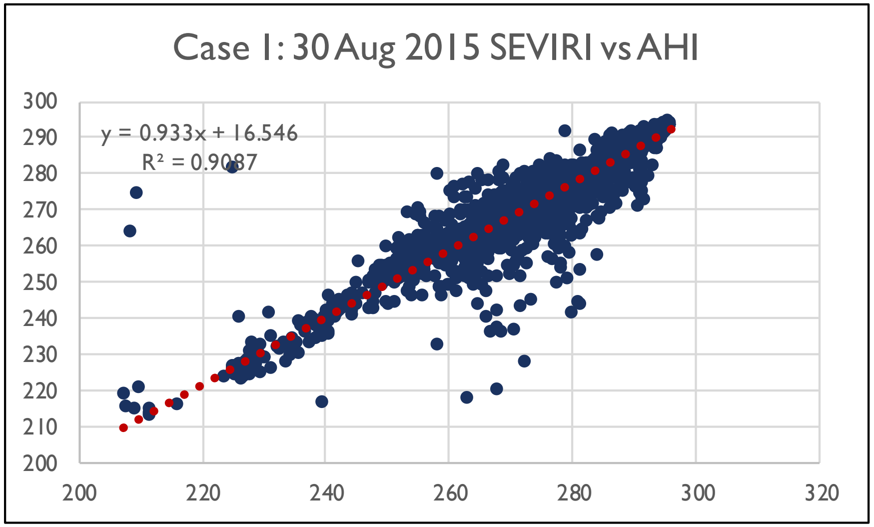


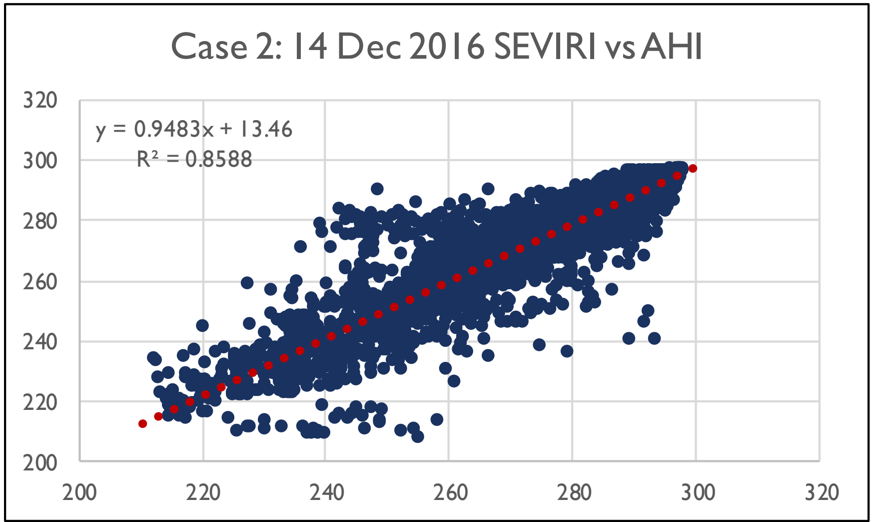
LINEAR REGRESSION: BLUE COMPONENT ADJUSTMENT

- Scatter plots and linear regression for two case studies used to determine recipe adjustments

Night-time Microphysics RGB				
Component	Band/Band Difference	Min	Max	Gamma
R	12.0 – 10.8	-4 K	2 K	1.0
G	10.8 – 3.9	0 K	10 K	1.0
B	10.8	243 K	293 K	1.0

- For Case 1, new range = -244.2 to 292.1
- For Case 2, new range = 243.9 to 291.3
- JMA adjustment = 243.6 to 292.6
- Results suggest adjustment:
  - Is not seasonally dependent
  - Is on par with JMA adjustments which were based on simulated data

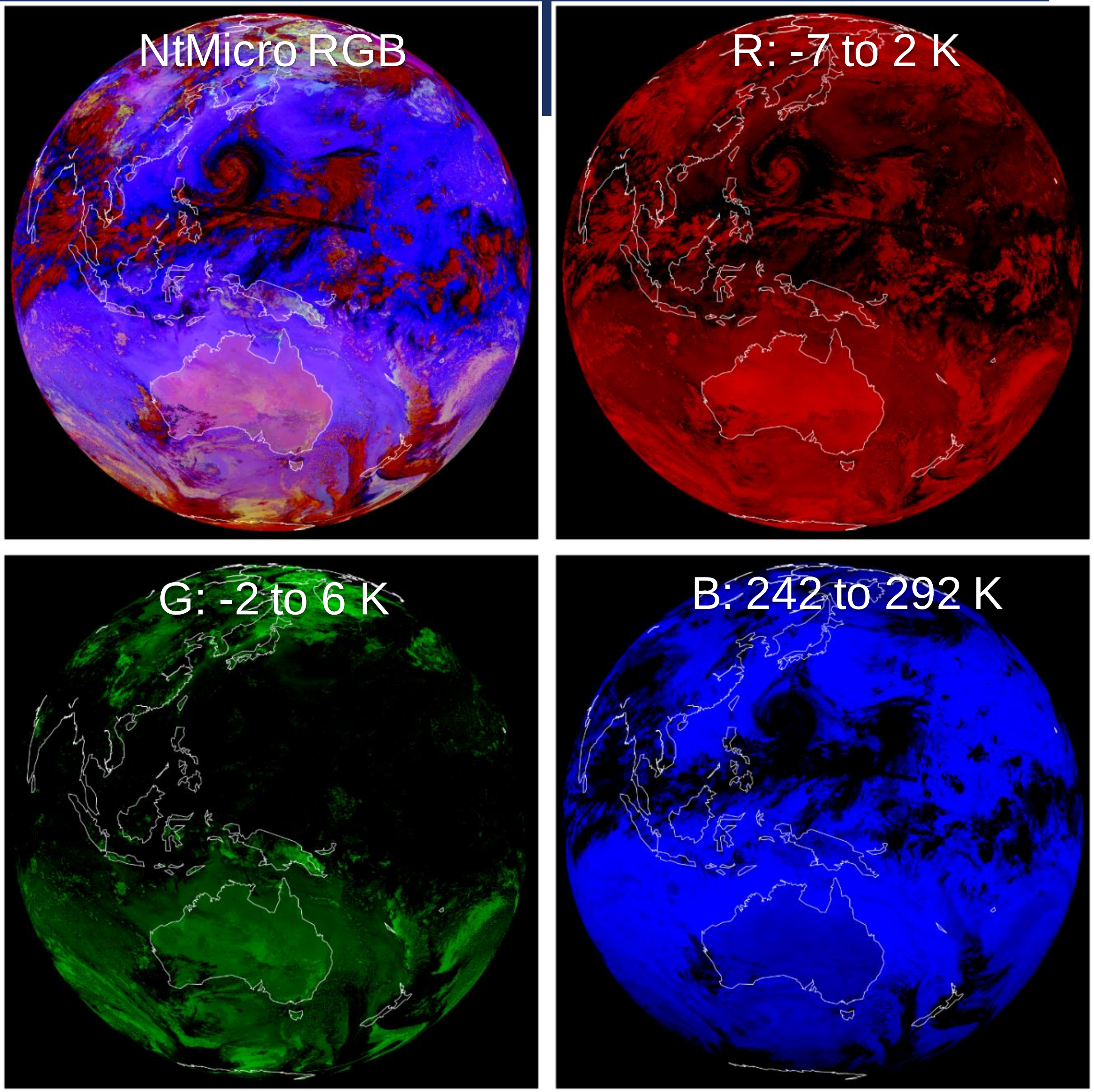




RECIPE ADJUSTMENT

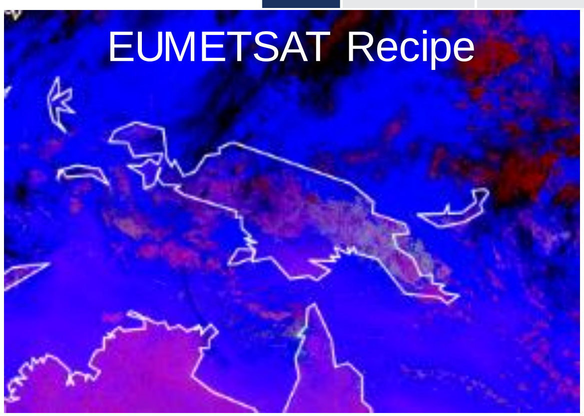
- With the new adjustment RGB colors and component intensity are similar to the SEVIRI proxy overlay (SEVIRI overlay barely visible!)
- Adjustment improves the lack of red and green intensities noted earlier
- RGB colors are consistent with legacy interpretation and training

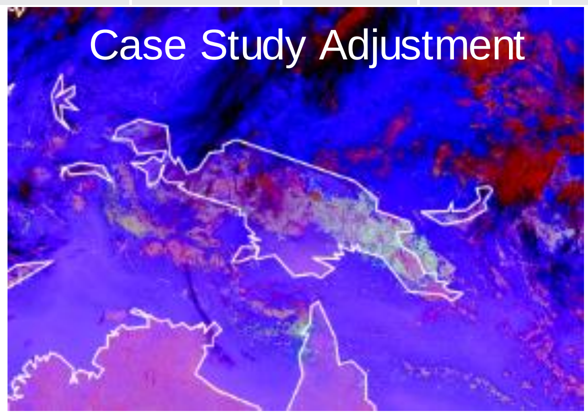
*note: applied adjustment to case other than which it was derived

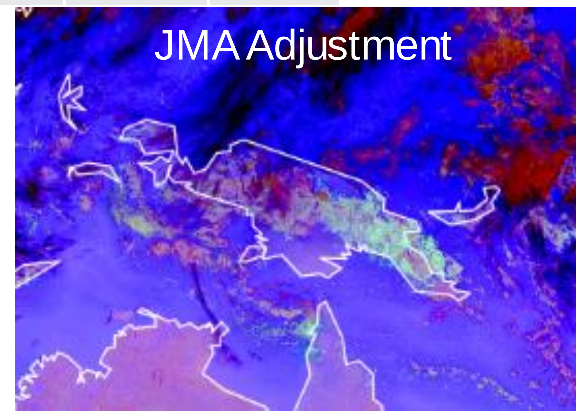


RECIPE ADJUSTMENT

	EUMETSAT			Adjustment by Case Studies			Adjustment by JMA		
	Min (K)	Max (K)	Gamma	Min (K)	Max (K)	Gamma	Min (K)	Max (K)	Gamma
R	-4	2	1	-7	2	1	-6.7	2.6	1
G	0	10	1	-2	6	1	-3.1	5.2	1
B	243	293	1	244	292	1	243.6	292.6	1







- Both adjustments improve the aqua coloring of the low cloud/fog features
- Slight color differences between case study and JMA adjustments attributed to the ability to account for instrument bias, noise, and full atmospheric absorption when using real data
- Since the adjustment is similar to what JMA derived for AHI, this research verifies work done by JMA and demonstrates a methodology to determine recipe adjustments for RGB imagery derived with GOES-R and GOES-S in the future

SUMMARY

- SPoRT has invested research in creating consistent Multispectral Composite (i.e. RGB) imagery across different sensors onboard polar-orbiting and geostationary satellites
- Differences in band central wavelength, bandwidth, response functions and atmospheric absorption between sensors can result in inconsistencies in an RGB composites from sensor to sensor
- This research presented a methodology to adjust RGB recipes to account for differing spectral characteristics between sensors through case study analysis including:
  - Comparison with a reference radiometer
  - Linear regression
- This methodology was applied to the Night-time Microphysics RGB derived from AHI and
  - Resulted in adjustments similar to JMA
  - Demonstrates a methodology to adjust RGB recipes for GOES-R and GOES-S
- Although not shown the methodology was applied to adjust recipes for the Dust, Ash, and 24-hour Microphysics RGB composites
- The methodology can be applied to visible and water vapor bands to derive recipe adjustments for additional EUMETSAT RGB composites

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QUESTIONS?

SPoRT

Short-term Prediction Research and Transition Center

http://weather.msfc.nasa.gov/sport/

https://nasasport.wordpress.com/

http://twitter.com/NASA_SPoRT

http://www.facebook.com/NASA.SPoRT